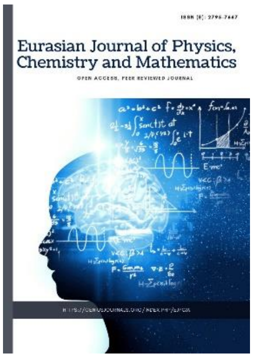

Study of surface condition of Bi-2212 bismuth-based cuprate sample by chemical imaging method

A.A.Turayev[1,3]
[1]Doctor of Philosophy in Physical and Mathematical Sciences, (PhD)
[2]Doctoral student of Bukhara State University

O.G.Turayev[2,3]
[2]Doctoral student of Bukhara State University
[3]Bukhara State University, Bukhara, Uzbekistan.

ABSTRACT

In the article, during the synthesis of the Bi-2212 cuprate sample, the change of the surface state of the sample under the influence of heat, the surface state of the sample after sintering was studied using the chemical imaging method. The irregularities on the surface of the sample were monitored and their dependence on the sintering temperature was studied. As a research object, we synthesized cuprate based on the formula $Bi_{2+y}Sr_{2-y}CaCu_2O_{8+x}$ and studied its properties. Assessment of sample condition by chemical imaging is an important factor for all types of cuprates.

Keywords: Bismuth base cuprate, B-2212, Chemical imaging, surface condition, sintering, spectral bands

Introduction. High-Tc cuprate superconductors are chemically, electronically and structurally inhomogeneous at the nanoscale. Although a body of theoretical work has predicted that local and global superconductivity may be dramatically impacted by particular dopant configurations, the exact positions of dopants introduced into cuprates to induce superconductivity are generally unknown. Here we use scanning tunneling microscopy to reveal the intra-unit-cell location of two different types of oxygen dopants in $Bi_{2+y}Sr_{2-y}CaCu_2O_{8+x}$. Furthermore, we show the relationship between these interstitial oxygen dopants, oxygen vacancies, and a global structural buckling known as the supermodulation.[1] Many theoretical models of high temperature superconductivity focus only on the doping dependence of the CuO_2 plane electronic structure. But such models are manifestly insufficient to explain the strong variations in superconducting critical temperature Tc among cuprates which have identical hole-density but are crystallographically different outside the CuO_2 plane. That is why cuprates are so important for studying crystal lattices. [2]

Experimental methods

Synthesis method. BSSSO composition can be prepared using several different methods. Examples include solid state, sol-gel, wet chemical, and melt quenching. We used a solid-state reaction method to obtain a sample of Bi-(2212). The solid-state reaction method is one of the most widely used methods for the preparation of high-temperature and crystalline solids. At room temperature, solids do not naturally react with each other, and in order to do so, they must be heated to a much higher temperature. [3] In the process of synthesis, oxide substances are first taken as a basis. The required amount of chemical products is measured with high precision and ground into a fine powder using an agate mortar. The reaction starts spontaneously during mixing, as the temperature rises, the reaction accelerates, the crystal lattice begins to form, and the excess carbon and oxygen contained in the oxides are released into the air in the form of carbon dioxide. Mixing the powder is repeated several times. Prolonged mixing of the components is a very important factor for the correct formation of the crystal lattice [4].

Chemical imaging method. Chemical imaging is a chemical mapping technique in which spectra and time are simultaneously measured and analyzed to create a visual representation of the constituents. Chemical imaging measures overlapping spectral bands, where even intermediate spectral bands can be measured [5].

For chemical imaging, it is possible to acquire many data spectra measured on a given chemical component in a defined space-time interval. Alternatively, it is possible to select image planes in a given data spectrum and map their spatial distribution. As a result, the chemical spatial arrangement of the sample is described.

Results and disscusion

As mentioned above, the solid state reaction method was used to obtain the samples. The constituent elements of the selected composite material were selected according to the Bi(Pb)-Sr-Ca-Cu-O system. For this purpose, powders of high purity Bi_2O_3 (99.9%), $SrCO_3$ (99.9%), CaO (99.9%) and CuO (99.9%) were taken in appropriate proportions. The mass fractions of elements in 10 g of the mixture based on the formula $Bi_2Sr_2CaCu_2O_y$ are given in Table 1 below [6].

Table 1. The mass fraction of the elements in the mixture.

№	Element n=3	Mass fraction (gr)
1	Bi_2O_3	5,761177
2	$SrCO_3$	2,908644
3	CaO	0,346672
4	CuO	0,983507

The sample is prepared by solid state synthesis. Bi_2O_3, $SrCO_3$, CaO and CuO powders were obtained in the ratio of Bi:Sr:Sa:Su in the ratio 2:2:1:2 and were ground and mixed in an agate mortar for a period of time. The powder is then placed in a muffle furnace at 705^o C for 12 hours and allowed to cool naturally for 12 hours. Then it is removed from the oven and crushed for another 1 hour and placed in an oven at 780^o C for 12 hours. After that, the same grinding process is repeated. Finally, the sample is pressed into a pellet of 10 mm diameter and 5 mm thickness by dry pressing method and sintered at 880^{o}C for 12 hours. The process of cooling the sample took 15 hours in a natural state. The samples, cooled to room temperature, were sent to the laboratory to study their physical parameters.

The microscopic structure of the sample was studied by the **chemical imaging** method. The location of the components included in the Bi-(2212) sample was analyzed.

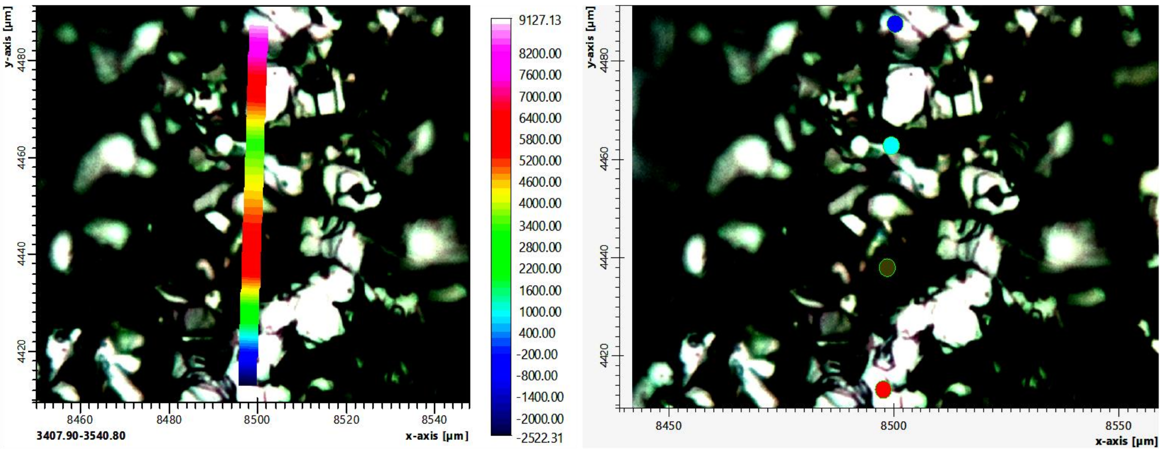

Fig. 4. Chemical imaging of Bi-(22212)

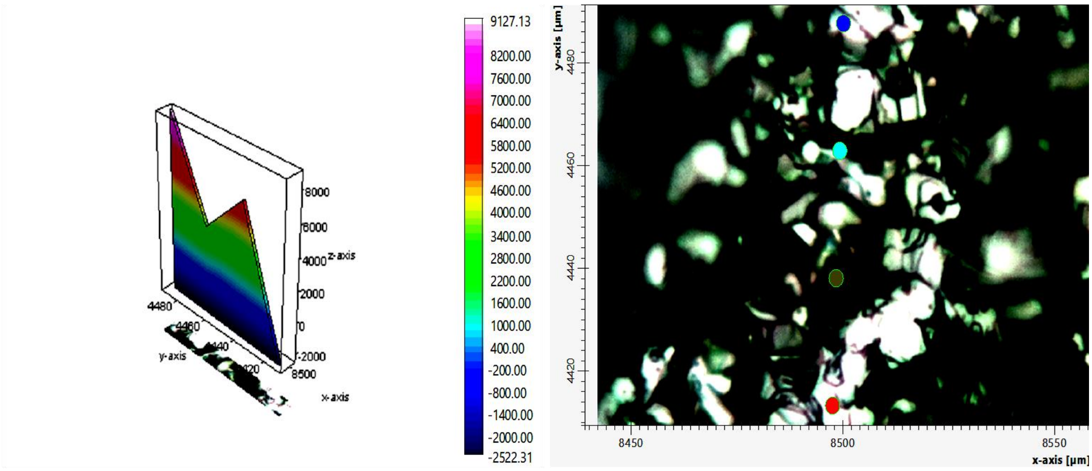

Fig. 5. Size distribution in chemical imaging 3D state

In the photos, the surface of the sample was studied in a section of different colors. Each color corresponds to a specific micrometer size. The blue dot is the deepest part of the sample. This value is x=2522.31 μm. The pink point is the highest part of the sample and corresponds to x=9127.3 μm .

Conclusions

The research concluded that in order to obtain a single-phase superconductor from Bi-based cuprate samples, it is necessary to sinter them at a temperature very close to the melting temperature. It was found that the sintering temperature and the flatness of the surface at which the sample is standing are the factors affecting the sample surface. In addition, the process of pressing the sample affects the surface condition. Based on the results presented above, it was found that even micro-sized irregularities can be eliminated and brought down to nano-size.

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